LAN/CBX: Planning for Change

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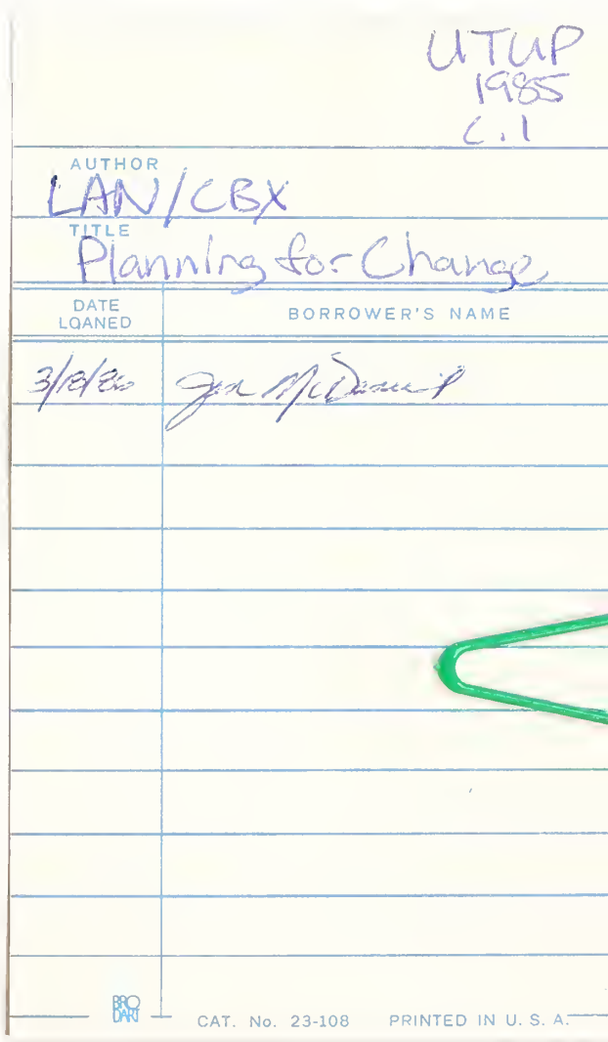


LAN/CBX: PLANNING FOR CHANGE

CONTENTS

EXHIBITS

I INTRODUCTION

- This report is part of INPUT's Telecommunications Planning Program. Designed to help apprise senior managers and corporate executives of the changes taking place in PBX, PABX (CBX), and LAN technology, and to identify the influencing factors associated with these technologically advanced fields. This report:

  - Identifies PBX and LAN communications requirements.

  - Defines and analyzes current and anticipated PBX and LAN innovations.

  - Analyzes the planning factors associated with PBX and LAN acquisition.

  - Identifies the thrust and direction of future PBX (CBX) and LAN development.

A. PURPOSE AND SCOPE

- Current PBX and LAN technology is in a state of flux, with rapid changes coming to each of these fields in increasingly shorter time intervals.

- For most managers and executives, it is a prodigious accomplishment just to remain current on the state of the technology, without having to anticipate the thrust of future developments.

- The requirements of a fully automated office have fundamentally altered the nature of PBX and LAN technologies, thus forcing change upon the functional definition of competing products. Consequently, a new set of vendors and competitors is beginning to emerge from among those companies currently identified most strongly with data processing, office equipment, and the communications industries.

- As the technology continues to expand, the basic offerings in both PBX and LAN technologies also change. Capabilities are being add while limitations are being removed. This adds a burden to the manager's role of evaluator and compounds the problems of differentiation, selection, and acquisition of both equipment and services.

B. REPORT ORGANIZATION

- This report is organized as follows:

  - Chapter I is an introduction.

  - Chapter II is an executive summary. It is formatted as a presentation for group discussion and emphasizes the key points within the report.

  - Chapter III is a technological assessment of the field and includes a survey of the technology available to date.

  - Chapter IV contains INPUT's conclusions and recommendations to support the manager's decisions regarding LAN/CBX acquisitions.

C. METHODOLOGY

- The information contained in this report was derived from the following sources:
  - Structured interviews with personnel from companies using or planning to install a LAN or a CBX.
  - In-depth interviews with some of the leading LAN/CBX vendors.
  - INPUT's studies on executive workstations, micro-to-mainframe communications, and LAN/CBX technologies.
  - An analysis of vendor-supplied product literature.
- INPUT has taken the best LAN/CBX practices and proposals and subjected them to further analysis to serve as a basis for this report.

D. OTHER RELATED INPUT REPORTS

- Interested readers are referred to the following INPUT reports:
  - End-User Micro-Mainframe Needs.
    - Concentrates on the experiences of organizations that use PC-to-mainframe systems. It also identifies systems requirements and projects future effects.

- Micro-Mainframe: Telecommunications.

  . Analyzes, in detail, personal computer communications modes, their advantages and limitations, and how these communications are likely to change in the next two to three years.

- Local Area Networks: Directions and Opportunities.

  . Focuses on the realities of LAN technology and implementation. Actual experience is emphasized and vendor claims are critiqued.

- LAN/CBX Trends: Decision Processes for Users.

  . Provides a definite planning document which explores technological capabilities, planning issues, and economic considerations associated with LAN/CBX selection.

- Telecommunications Annual Planning Report.

  . Defines and analyzes the entire spectrum of telecommunications technology and evaluates the requirements and planning issues for selecting the correct technical solutions.

- Integrated Voice/Data Communications.

  . Analyzes the requirements and possibilities for integrating both voice and data and identifies specific obstructions that have delayed or withheld such integrations from the marketplace.

II EXECUTIVE SUMMARY

- This executive summary is designed in a presentation format to:
  - Help the busy reader quickly review key research findings.
  - Provide an executive presentation and script that facilitates group communications.
- The key points of the entire report are summarized in Exhibits II-1 through II-6. On the left-hand page facing each exhibit is a script explaining that exhibit's contents.

A. PBX DEVELOPMENT: THE GENERATION GAP

- The first generation includes electromechanical, electronic step-by-step crosspoint, and crossbar switches.

- First of the so-called intelligent PBX's, the second generation features a central processing unit for stored program control, analog space-division switching, and pulse code modulation coupled with time-division multiplexing.

- More a matter of degree than function, the third generation handles both voice and non-voice signals over twisted pair circuits, using inexpensive microprocessors and distributed architecture.

- The fourth generation is highly modular and distributed, and integrates a LAN. It is specifically designed to integrate voice and data, whereas earlier PBXs added data-handling ability as an afterthought.

  - The identity of the first fourth-generation switch is a matter still in dispute. Some say it was the 1981 Datapoint ISX; however, United Telecom claims its UTX 1001, also introduced in 1981, was first.

  - The label "fourth generation" might be considered marketing hype, since manufacturers seek to differentiate their products. However, there are some distinct differences in the technology.

PBX DEVELOPMENT: THE GENERATION GAP

GENERATION	MAJOR FEATURE
1st	Electromechanical, Stepping, and Crossbar Switches
2nd	CPU with Stored Program Logic Control
3rd	Microprocessors and Distributed Architecture
4th	LAN and Full Data Capability

B. FOURTH GENERATION IS STILL EVOLVING

- Early generations of PBXs were designed primarily for voice switching. Data switching capabilities were added in the third generation. The so-called "fourth generation" is designed specifically for integrated communications, as the central controller for the office of the future.

- All use twisted pair circuits as the primary transmission media. This offers economical access in existing buildings.

- Generally, all manufacturers design their products to be flexible and adaptable to various customer needs. Features of this product planning for CBXs include expandability and an increased number of functions.

- Because of modular growth capability, CBXs are designed to be useful for an extended period.

- Each successive generation has proved a bigger "tool" to resolve basic transmission capabilities. The later the generation, the bigger the unit, both in terms of physical size and designed abilities.

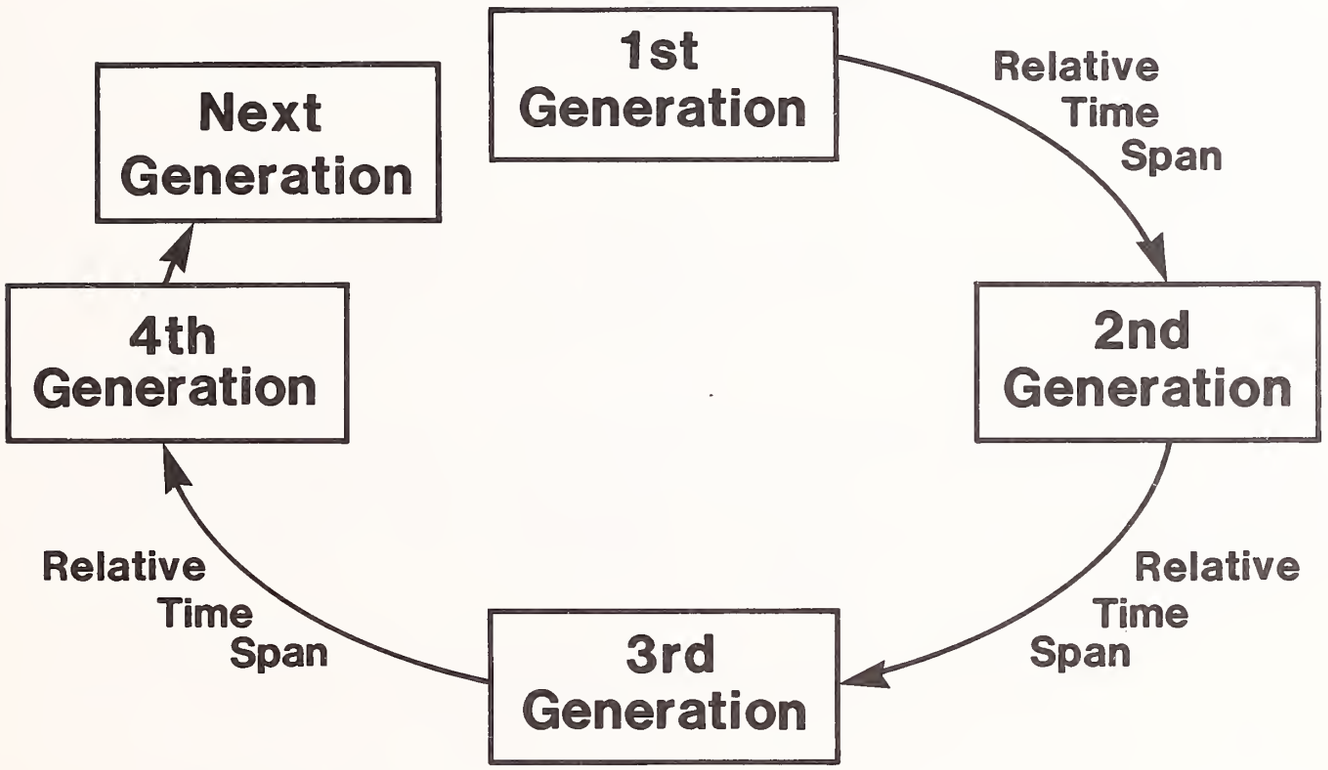
  - Analog and digital are now both supported, as are voice store-and-forward and electronic mail.

  - T1/T2 facilities are provided, along with LAN interfaces and mainframe interfaces.

- The fourth generation is more heavily software oriented than its predecessors.

- The time span between successive PBX generations is shrinking as development is accelerating. Over this compressed time interval, greater use of the equipment is necessary to recover capital costs.

FOURTH GENERATION IS STILL EVOLVING



C. CBXs HAVE COMMON CHARACTERISTICS

- Universally, CBXs have certain common characteristics. These are summarized in Exhibit II-3.

- Voice and data are fully integrated. Transmission is on the same twisted pair. Ideally, the same ports are used for both voice and data.

- Integrated LAN functions include:

  - High speed.

  - Enough bandwidth for present and future office automation applications.

  - The possible eventual inclusion of switched full-motion video abilities.

- Distributed intelligent architecture means that:

  - Each module or node can be considered an independent CBX that supports a number of stations, instruments, or data extensions.

  - Many "switches" act in concert, each with processing ability, and are not controlled by a central unit.

  - A redundancy feature ensures that integrated diagnostics and monitoring systems will automatically reset to back-up cards in case of failure.

  - Each node has a data base of features and user addresses.

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COMMON CBX CHARACTERISTICS

- Full Voice/Data Integration
- Integrated LAN
- Distributed Architecture
- Digital Instruments
- Dual Bus Architecture: Packet Data and PCM Voice

D. THE DIGITAL PBX PROVIDES FLEXIBILITY

- In the fully automated office, all digital devices might radiate out of the communications controller or CBX, using twisted wire pairs and coaxial cable links. Whether the switching is via a local network or over remote links, it will be handled by a common controller logic and will be transparent to the user.

- The CBX features nonblocking. This means that although data transmission requires more time than voice, the system is designed to handle increased traffic. Using fixed time slots for each port, nonblocking time slot allocation eliminates the hardware and software previously used for time slot control.

- Layered software architecture is standardized and structured like a computer's, based on the International Standards Organization's (ISO) reference model for open systems interconnection.

- Distributed architecture built into fourth generation connects the central switch to remote nodes via fiber optics or coax cable.

- Ideally, the product includes format, protocol conversion, 3270 terminal emulation capability, and direct T1/T2 carrier connection to the central office. Synchronization is maintained on both ends of the connection.

- Because of modularity, additional line costs are nearly constant, and independent of system size and features. Since functions can include integrated automated building management, security, utilities, and energy controls as well as data and voice communications, true costs are lower than those for other configurations or standalone systems serving these needs.

- The ability to handle voice and data on an equal basis without separate transmission paths is a characteristic of fourth generation CBXs.

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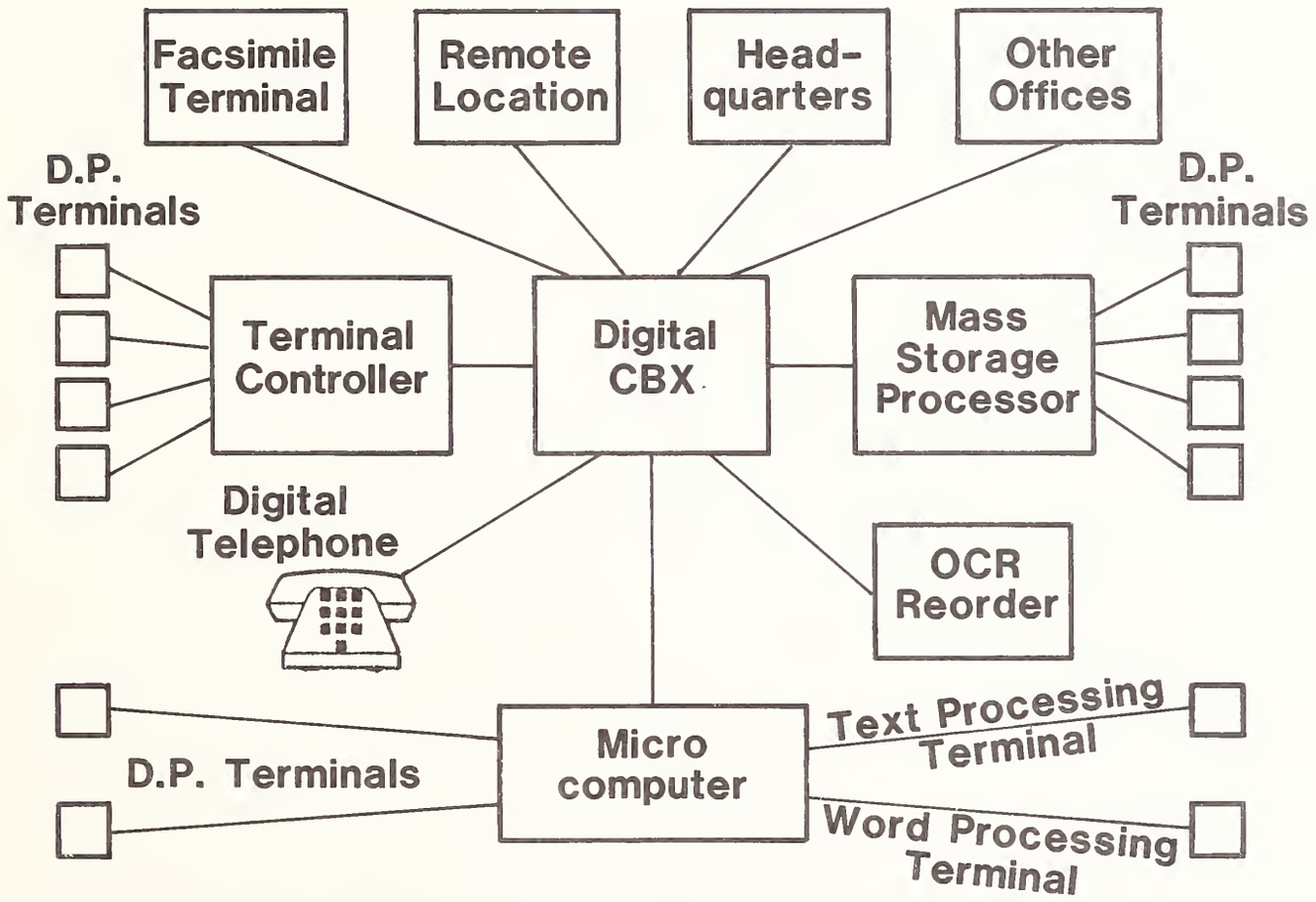
THE DIGITAL PBX PROVIDES FLEXIBILITY



E. LANs: A SIMPLE SOLUTION

- A local area network:
  - Is company owned and is not subject to FCC or other government regulations.
  - Integrates various equipment and applications on the networks, including data processing, electronic messaging, images, and voice.
  - Supports full connectivity. Ideally, every device can communicate with every other extra device.
  - May bridge to other similar LANs or may have gateways to dissimilar networks.
  - Runs at high speed; LAN speeds range from 500 Kbps to over one billion bps (on fiber optics).
- LANs are generally installed in situations requiring large bandwidth and supporting heavy traffic between and among workstations, peripherals, and central computers.
- LANs were developed in the data processing industry. Their use eliminates the need for a standalone data network by integrating data communications links with functional access to a wide variety of peripherals, controlled by the network's designed intelligence.

LANS: A SIMPLE SOLUTION

- Corporate Ownership, Unregulated
- Integrates, Connects All Equipment/ Applications
- Bridges/Gateways to Other Networks
- High Speed/Wide Bandwidth

F. IMPLEMENT LAN/CBX PROACTIVE STRATEGY

- Carefully assess the individual features of both PBXs and LANs. Because of the multitude of capabilities of PBXs, evaluate environmental requirements versus device capabilities.

- LANs tend to be more complex in their operation than PBXs, especially since even a LAN requires some sort of switching mechanism. Yet LANs are a good solution for avoiding excessive transmission costs, especially if AT&T transmission systems are used.

- From a capital cost point of view, LANs may be a cheaper investment over the long run than a multitude of PBXs. A detailed cost analysis on a point-by-point basis may be the wisest decision-making tool.

- There has been considerable talk about "fifth generation" CBXs, but there is little solid evidence of a truly "fifth generation" CBX system available in the marketplace at this time.

- The competition between PBX and LAN vendors will increase. The intensity of competition will generate many claims that may not apply to a particular organization. Identify the company's communication needs for at least five years. Then purchase equipment with both the data and voice needs in mind. Purchase proven technology. In many organizations, the burden of support and customer satisfaction will reside with IS. The success of future information system applications will depend on telecommunications in general and local networks in particular.

INPUT®

IMPLEMENT LAN/CBX PROACTIVE STRATEGY

- Assess LAN/CBX Product Capabilities
- Avoid Excess Transmission Costs
- Evaluate Capital Investments
- Beware of Unwarranted Vendor Claims
- Use a Five-Year Planning Horizon
- Incorporate LAN/CBX into the IS Strategic Plan

III TECHNOLOGICAL CONSIDERATIONS

A. INTRODUCTION

- PBX, PABX, and CBX are acronyms for a class of telephone switching facilities which are "branched" from the public switched telephone network.

  - Traditionally, although not necessarily correctly, the terms PBX and PABX are synonymous.

  - Technically, a Private Branch Exchange (PBX) is basically a manually operated interface between the originating telephone caller and the outside world; service requests must pass to the switch operator for implementation.

  - The Private Automatic Branch Exchange (PABX) is generally automatic in that service requests can be forwarded by the originating caller directly to the switch which, according to its hardware or software logic, dutifully carries them out.

- Most often one exchange services those stations located on the same premises as the switch; there are, however, many instances in which one PABX, or several PABXs, may be configured as part of a private telephone network.

- Some of these private networks can become rather complex, involving interstate tie lines, tandem switches, foreigh exchanges, etc.

- A PABX can be configured to satisfy a user's individual telecommunications requirements.

- Exhibit III-1 shows a representative PABX configuration using a PABX as a communications hub. By dialing a series of digits or other codes, a system user can access various system features or outgoing trunks. Most business telephone users are familiar with the instruction "dial 9 for outside calls," and this code is generally reserved for local central office (CO) access.

  - Other codes might be reserved for foreign exchange (FX) trunks (leased lines that extend the reach of a PABX into another area--usually a long distance location). In use, the switch would immediately seize the requested trunk.

  - FX trunks, WATS lines, tie lines, etc., are all designed to limit the money spent on direct distance dialing charges, and are desirable when distant locations are destinations of high-volume calling.

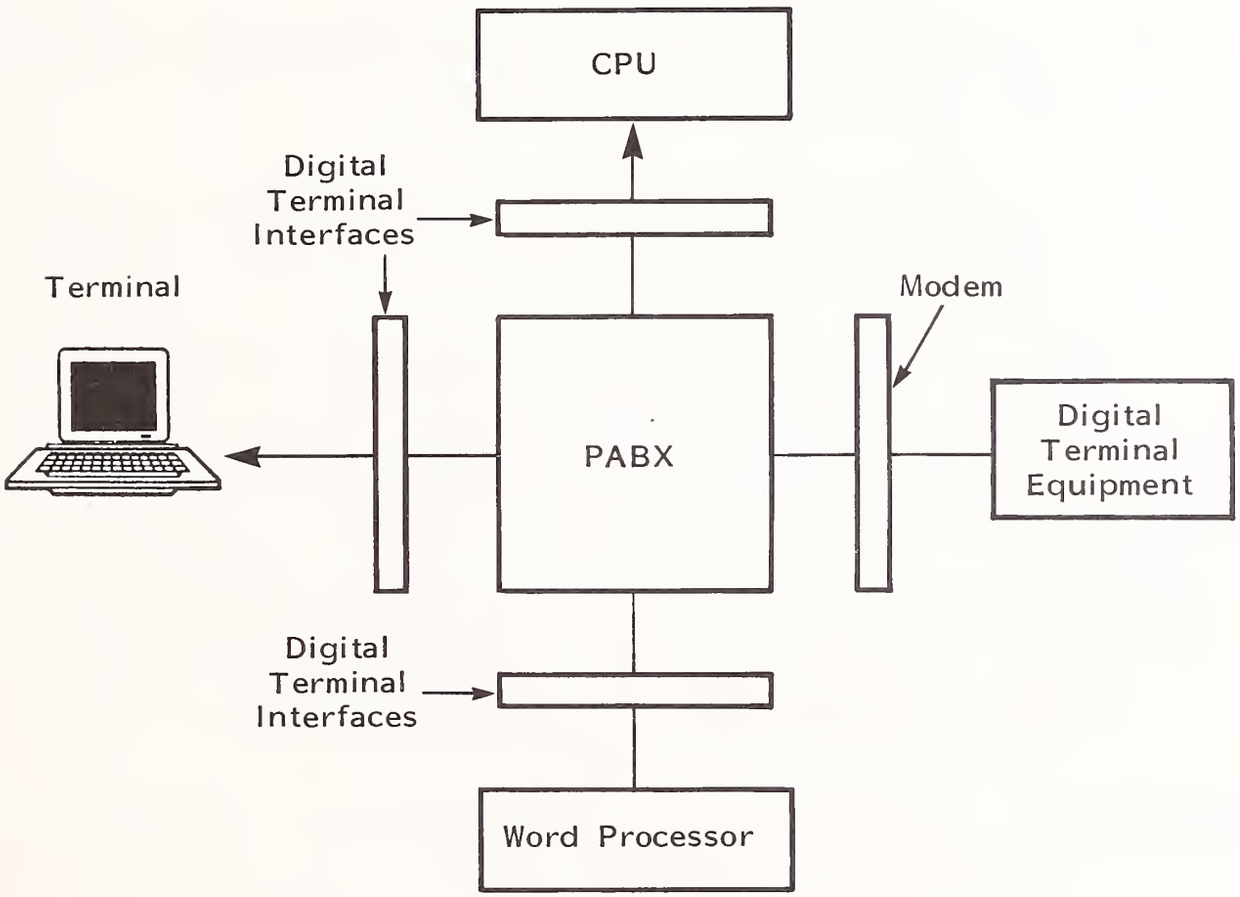
- Traditionally, large corporations, hospitals, hotels, certain government agencies, and other volume telephone users have comprised the installation base for PABX systems.

  - However, the past several years has been a period of rapid growth in the medium- and small-scale system markets, as lower volume customers seek similar cost reductions and telephone management systems that large users have enjoyed for years.

- As quickly as the customer base is broadening, the tasks placed upon the PABX are expanding in complexity. Most of the pressure is coming from user demands to incorporate data processing transmissions with the transmission of

EXHIBIT III-1

REPRESENTATIVE PABX COMMUNICATIONS CONFIGURATION



voice over the same facilities, either as discrete digital information or via modems (modems convert digital data into frequencies compatible with the public switched telephone network).

- Exhibit III-2 illustrates that these integrated PABX systems may use two separate paths for the voice and data signals or may share a common circuit for both by employing a multiplexing technique.

- Data communications is the glue which will integrate diverse data devices into an effectively automated office environment.

- Without the proper data communications environment, office automation will be avoided because it will not be cost effective.

  - As more PABX manufacturers incorporate integrated voice and data handling capabilities, the PABX will, during the remainder of the 1980s, often be the vehicle that ties together the elements of the automated office.

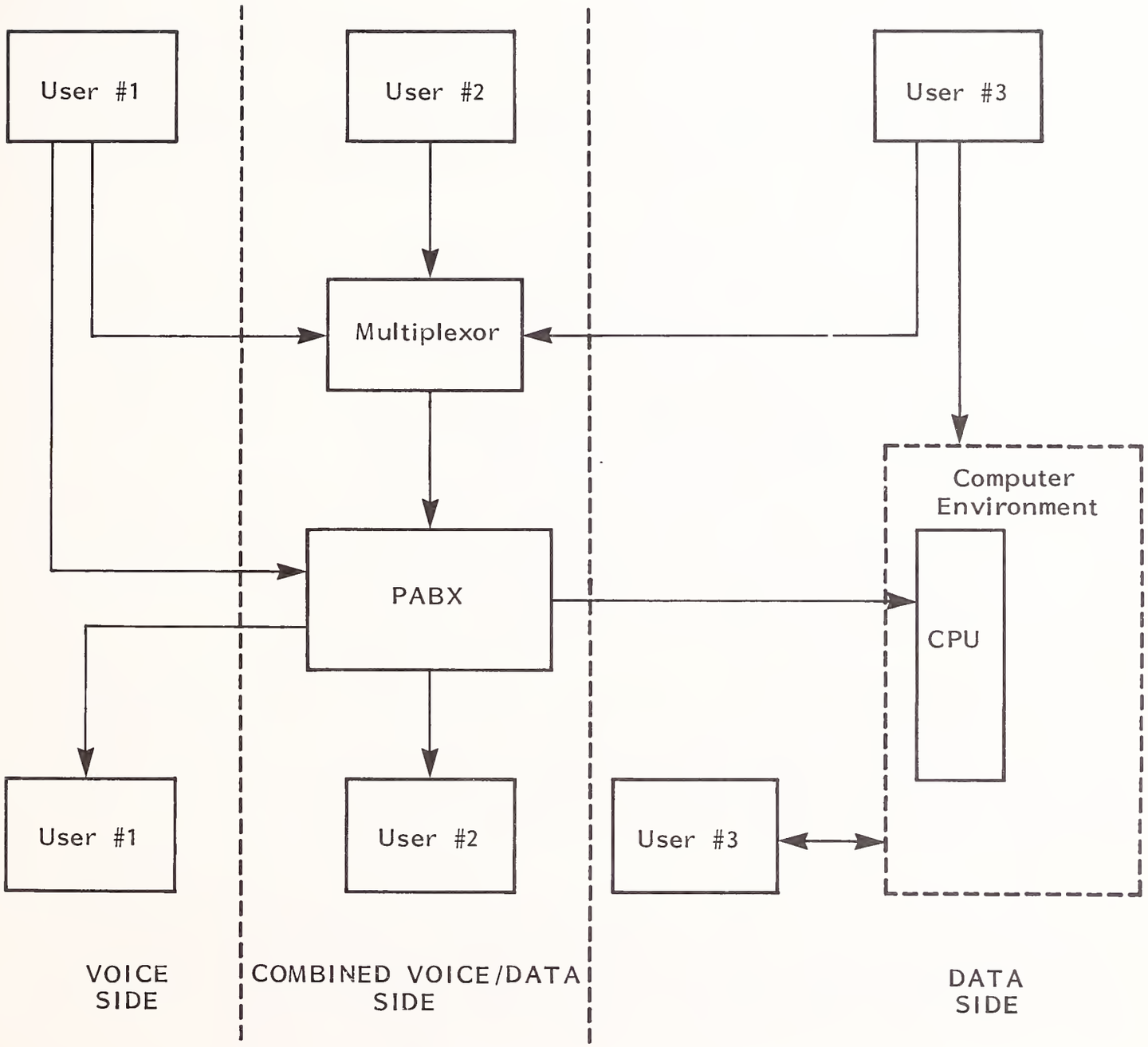
  - Third generation digital PABXs have already begun to dominate the office environment, and fourth generation equipment is starting to replace many of the old first and second generation PBXs.

  - Once a PBX is digitized, it is usually referred to as a Private Automatic Branch Exchange (PABX).

  - But a new term is coming into common usage. The term "CBX," which may be defined as a fully Computerized Branch Exchange. Throughout the remainder of this report, the term CBXs will be used to refer to PABXs that are fourth generation (or beyond).

EXHIBIT III-2

REPRESENTATIVE PABX TRANSMISSION PATHS



B. TECHNOLOGY REVIEW

1. BACKGROUND

- The oldest automatic switching technology, first introduced in the 1890s and still widely used, involves an electromechanical process known as step-by-step (S x S) switching. Probably the most notable example of this type of switch is the Stronger switch.

  - In S x S switches, a circuit path is established sequentially as a contact wiper arm is positioned by the pulsing current produced by the make/break action of the telephone dial. The wiper arm can be stepped vertically through ten levels, and each level has ten contact points over which the wiper arm can be positioned.

- Generally, step-by-step switches are directly controlled mechanisms; that is, the vertical and horizontal motions of the wiper arms are dictated by the signals produced by the operating station set.

  - Another technology, announced during the World War I, separates the control and switching functions of the circuit switching systems. In common-control switching systems, a central controller oversees the establishment of a voice circuit through the switching network.

  - One call is handled at a time; once the circuit path is established the controller is free to handle another call. In this manner, a small amount of system control can be used to supervise the connection of a large number of calls.

  - Initially, common control methods were used with crossbar and reed-relay switches, but later the common control principles were adopted for use with fully electronic telephone switching systems as well.

- Step-by-step, crossbar, reed-relay and some integrated circuit (IC) matrix switching networks can be considered space-division systems in which a transmission circuit is physically established and subsequently maintained for the duration of a call. No other call can use the path simultaneously unless it is deliberately bridged for the purpose of conferencing, etc.

  - Another method of allocating available network capacity involves what is called time-division.

    . In time-division networks, a pathway (variably referred to as a highway or bus) is used to carry a number of conversations simultaneously.

    . Each conversation is allotted a portion of the bus by being assigned a time slot; and only those telephones with identical time assignments can converse.

  - In one time-division switching technique, each terminal is interfaced to the common bus via a gate which is activated to an "On" condition at a specific time interval.

    . The switch samples each terminal momentarily at a high frequency, generating a series of pulses with amplitudes (height) directly proportional to the original waveform of the voice conversation.

    . These pulses are combined with those representing other conversations, and transmitted over the common highway as a pulse amplitude modulated (PAM) wave train.

- Theoretically, the maximum number of conversations that can be carried on a Time Division Multiplexed/Pulse Amplitude Modulated (TDM/PAM) pathway is

solely a function of the sampling rate (frequency) and interval (width). However, certain limitations are imposed by the band of voice frequencies to be modulated, and by the width and spacing of the resultant pulses to be multiplexed.

- Voice signals convey most of their intelligence in the frequency range of 300 Hz to 3000 Hz.

  . Thus, the telephone network has been established to function most efficiently in this range.

  . To pulse amplitude modulate such a range requires a sampling rate at least twice the highest frequency to be transmitted--6000 Hz.

  . A lower sampling rate decreases the "intelligence" or information content of the resultant PAM pulse train.

  . Pulses generated at lower sampling frequencies cannot be reconstructed (demodulated) back into intelligible voice signals.

- Most PAM CBX switching systems on the market sample at 8000 Hz (8K Hz) rates, well above the 6K Hz minimum; a few switches sample at even higher frequencies.

- Gate circuits require a finite period of time to generate pulses and respond to them. Thus, limitations are placed on minimum time slot (pulse width) duration and on the minimum time period separating each distinct pulse in the PAM train. The longer the duration and spacing, the smaller number of pulses that can be packed onto a common highway.

  - Time-division networks, like their space-division counterparts, can only switch a finite number of terminals, with each time slot being the equivalent of a connection path in a space-division matrix.

- The total number of time slots determines the degree of blocking within the system.

- The space- and time-division switching techniques discussed to this point have involved processing analog signals--electrical analogs in voltage (amplitude) variations.

  - Such switching systems are classed as analog space-division or analog time-division.

  - Another class of switches uses a digital, or binary, representation of the voice waveform. Speech information is transmitted via a series of constant amplitude pulses--a digital signal which portrays source information by discrete binary pulses trains or by pulse duration within the train.

- Pulse code modulation (PCM) is the most common method employed in digital switching systems.

  - Such systems take PAM encoded representation of a voice signal and assign a specific digital code or number to a designated pulse amplitude. Thus, a sine wave analogous PAM signal is converted into a digital PCM signal. This signal is, in turn, time-multiplexed onto a common highway.

  - Typical sampling rates are at 8K Hz, with each sample usually encoded into an 8-bit binary number.

- Delta modulation (DM) employs a different concept to digitize the analog voice waveform.

- Only a single bit defining the positive or negative slope of the waveform during a small time period is transmitted per sample. Sampling occurs at higher rates, typically 50K Hz or greater.

- The DM digital pulse, like that of PCM, is multiplexed in time over a common highway.

- Almost coincident with the emergence of digital modulation technologies was the introduction of stored program control to switching systems.

  - In the classic sense, all common control associated with switching employs some form of stored program. Such programs reside in the hardware of the system and are difficult, if not impossible, to change.

  - Storage is fixed, and control functions are frozen on a specific number of routines wired into the system.

  - The present usage of the term "stored program" denotes programmable processor or computer (minicomputer, microcomputer) control where software operating routines are employed.

    . Such software programs often are loaded (written) into and reside in random access memory (RAM).

    . If a feature update is issued for the switch, the old control program can be unloaded (erased) from RAM and a new program loaded with a minimum of effort via magnetic tape, disk, or terminal keyboard.

2. CBX CAPABILITIES AND LIMITATIONS

- The following summarizes the more important features and functions of CBX switching systems now on the market.

- In some CBXs, a variety of memory and backup storage devices are utilized on the switch: protected segments of RAM memory, read-only memory (ROM), or programmable ROM (PROM); any of these may be used to hold semi-permanent operating routines. Changes to these routines are usually rare, but can be accomplished by accessing RAM, or by replacing ROM or PROM elements.

  - The availability of trunk circuits to support such traffic loads must be considered when configuring the overall system. A poor mix of trunks to extension lines and/or improper grouping of trunks on the switch can introduce blocking from the external public network facilities rather than from the switch.

- Magnetic tape storage is often used to load RAM or backup RAM on some systems in the event of power failure. Most RAM utilized on a system is volatile--the contents of the memory are erased if power is removed. A mag tape module is employed to reload the memory in such events. Other switching systems eliminate the need for such tape backup by protecting RAM with an independent power source.

- The type of switching technology employed may be analog or digital, space- or time-division matrices, in association with a particular modulation scheme.

  - At present, the relative advantages to the user between analog or digital systems, between space- or time-division, between PCM and DM, etc., are confusing to most users.

  - Differences relating to switching technology may be found in the transmission parameters of the switch (crosstalk, loss, noise, etc.).

  - In most applications involving the switching of voice signals, such differences are minor, and can be neglected in the overall evaluation.

Otherwise, switching technology considerations for voice telephone applications can take second place when compared to system control, capacity reliability, and price-performance factors.

- An important feature is system capacity, which identifies or defines the maximum number of station (telephone extension or set) lines, trunks, and operator consoles that can be accommodated by the switch. This is generally a fixed number.

  - In some instances, these values are not mutually exclusive of other system parameters. A maximum system configuration might support combined line and trunk maximums lower than those cited by the vendor's sales literature.

- Tenant groups denote the total number of users or departments that can utilize the features of the switch on an independent basis. Such groups have access to their own dedicated trunks and call accounting, and, in some configurations, their own operator consoles.

- System traffic handling capabilities provide information on the maximum number of simultaneous conversations that can be handled by a CBX system at a time. The term CCS/line is frequently used to indicate the traffic density per line (line occupancy rate, call duration, or holding time) in hundred-second call units (traffic in seconds x 100).

  - The P factor denotes the probability that a call will be blocked by the switch. A P factor of 0.01 means that 1% or 1 call in 100 will be blocked because all switch voice paths are busy. Note that grade of service is a function of the traffic density (CCS/line) carried by a specific CBX configuration of lines and trunks. The higher the traffic density, the lower the grade of service for a fixed configuration.

- The number of calls per hour that can be accommodated by a switch can be estimated if the average call traffic density and number of simultaneous conversations supported by the switch are known.

- The number of calls per hour equals 3600 times the number of simultaneous calls divided by the call density in seconds.

- In a general office environment, the average is about 5.2 CCS/line (520 seconds). Thus, for a switching system with capability of supporting 64 simultaneous calls, the number of calls accommodated is (3600 X 64)/520 or 443 per hour.

- For a hotel/motel facility, call density is about 3.2 CCS/line; the same switch could accommodate 720 calls per hour at this density.

- For a high volume telephone sales or reservations environment, call density is approximately 9.5 CCS/line; only 243 calls per hour could be accommodated at this average density.

- Note that these estimates on the typical calls per hour supported are based on approximate traffic densities, and relate only to the internal capabilities of the switch itself.

• In order to make valid CBX capabilities assessments, the IS manager needs to determine which class (or which specific feature) or category of feature he needs, evaluate the basis for that need, and define its priority. Once that has been determined, he can then specify exactly which features or capabilities he requires within each specific category. These become the features his system will possess when his CBX is ordered or installed.

- Exhibit III-3 illustrates, in simplified format, the charting of feature versus need.

EXHIBIT III-3

CBX PLANNING CONSIDERATIONS

PRIORITY	STATION ORIENTED FEATURES				
	Call Restriction Features	Conference Service Features	General Features	Attendant Features	Station Features
Urgent Need					
Strong Need					
Possible Need					
No Need					

- To a greater degree, CBX and Key Telephone System product lines are converging.

  - The cost reductions and improved technical performance attributable to solid-state electronics and computerized stored-program control are making it increasingly economical to produce both small, cost-effective CBXs and larger Key Systems with considerable functional capabilities.

- Both CBX and Key Systems use essentially the same technology. Several major manufacturers and suppliers offer both CBXs and Key Systems.

  - The popularization of stored-program control for smaller installations (typically, in the range of 20 to 60 telecommunications lines) makes CBX and Key System equipment directly competitive.

3. LOCAL AREA NETWORKS (LANs)

- The battle of advocates continues between those who favor LANs and those who favor digital CBXs as the ultimate solution for local data communication. A new generation of high-tech products attempts to settle the question by offering the best of both worlds. Two heavily capitalized startup firms, Ztel and CXC, have announced products that function as PBXs, but are physically token-ring local area networks or, more precisely, LANs with digital voice/data switches as nodes.

- A growing share of attention in the LAN market belongs to the "bridge" or "gateway" vendors.

  - A bridge is a device that links two local area networks of the same type.

- A gateway is a similar device, but one that performs protocol conversion between a local area network and a network of a different type, either a foreign LAN or a long-haul architecture such as SNA or X.25.

- Many vendors offer such products for their own local area networks. Some vendors, however, specialize, marketing only bridges and gateways.

a. LANs: A Definition

- For this report's purposes, the following definition is used.

  - A Local Area Network (LAN) is a system for the interconnection of two or more communicating devices that is:

    . Intra-company, privately owned, user-administered, and not subject to regulation by the FCC. (This definition excludes both traditional local connection over common carrier facilities, such as Bell System tie lines, and public local networks, such as the newly-approved Digital Termination Services and local cable television networks.)

    . Structured. In a local area network, many types of equipment and applications, such as data processing, word processing, electronic mail, video, and voice, can all operate over a single cable.

    . Limited geographical scope, with devices physically separated but not mobile. For example, devices may be on different floors of a building, on the same industrial or university campus, or in several buildings in the same city.

. Supportive of full connectivity. Every user device on the network is potentially able to communicate with every other user device.

. High speed. Minimum and maximum throughput generally ranges from 500K bps for low-speed LANs based on twisted pair wiring up to over one billion bps for experimental fiber optic LANs.

. Commercially available. Many LANs are either proprietary, and therefore not available to others, or are little more than laboratory curiosities.

- For a fuller discussion of what local area networks are and what advantages accrue through their use, please refer to INPUT's report entitled LAN/CBX Trends: Decision Processing for Users (October 1984).

b. LAN Benefits

- A local area network can support any application now served by conventional point-to-point communications. However, the implementation of a LAN can be a radical and expensive step, and hard to justify if its sole purpose is simply to replace an existing cable plant for tried-and-true applications.

  - A local area network can offer benefits not available, or simply too expensive, with conventional local communications. Some of the things that LANs can do best in broad areas of application include:

    . General business data processing.

    . Office automation.

    . Industrial and laboratory automation.

    . Home utilization and entertainment.

c. Capabilities and Limitations of LANs

- Today's local area network is a fairly sophisticated engine for moving several streams of bits concurrently, rapidly, reliably, and inexpensively from one physical interfact to another. Still, every major advantage now offered by a LAN is balanced by one or more restrictions (refer to Exhibits III-4 and III-5). Some of these restrictions are built into the technology, while others will fall as vendors and standardization advance the state of the art.

- The ability to integrate a wide range of functions into a single, harmonious system is another advantage that LANs offer, since the local area network can provide a rational framework around which management can build everything from office procedures to strategies for planning, purchasing, and growth.

- A high rate of data transfer is inherent in any definition of a local area network. Most LANs transfer data at rates from 1 Mbps to 10 Mbps, and high-performance LANs can achieve rates up to 50 Mbps.

- Most local area networks use a simple and elegant architecture with control distributed among the participating stations. Since the entire network does not depand on a single polling or switching device, such networks tolerate failures quite well.

- No system or hardware is a panacea, however attractive it may seem. The greater a technology's potential effect on an organization, the more carefully managers must plan its implementation. A local area network is only a tool. Creative management can make it a powerful tool.

d. LAN Technology

- In choosing a local area network, four basic issues must be addressed:

EXHIBIT III-4

LAN ADVANTAGES

- Uses high speed terminals.
- Several thousand feet in distance.
- Terminal can connect to multiple computers within the network.
- With terminal concentration, can provide chara-ter echoing and text editing services.
- Minimum host processing overhead.
- Permits file transfers over network at attractive rates (essential when using PCs).
- Provides common access to other TC facilities; e.g., satellite link or public packet network.

EXHIBIT III-5

LAN DISADVANTAGES

- Expensive Solution
- Provides more bandwidth than usually required to get the job done.
- Not the solution to all data communications problems.
- Diversity of equipment often means training and familiarization problems, and added costs.

- The network's physical medium and transmission technique.
- Its topology; the logical arrangement of its stations.
- Its access method; the way it arbitrates among its stations for the use of the shared medium.
- Any higher-level services the LAN offers, such as protocol or file format conversion, data encryption, or network management.

- Today's market offers three basic choices of medium:
  - Twisted wire pair.
  - Coaxial cable.
  - Optical fiber.
- Three choices of basic topology:
  - Linear bus.
  - Ring.
  - Star.
- Three choices of access method:
  - Carrier sense multiple access (bus and tree networks).
  - Token passing (bus and ring networks).
  - Slotted access (exclusively ring networks).

- The issue of higher-level services is somewhat more complex, since a vendor can offer such services above any practical combination of the other three factors.

  - However, right now, such services are only beginning to emerge as commercial offerings, and they depend heavily on specific applications.

- For a fuller discussion of the details of these various media, topologies, and access methods, please refer to the INPUT report Integrated Voice/Data Communications (June 1985).

4. PLANNING CONSIDERATIONS

a. Introduction

- The choice between a LAN and an integrated voice/data CBX is critical because it determines the backbone of the office automation system. The decision criteria for each technology are summarized in Exhibit III-6.

  - Consider the features of:

    . CBXs: Least-cost routing, message detail recording, voice store-and-forward, electronic messaging, paging, security levels.

    . LANs: Speed, capacity, gateways, integrated building services.

    . Data PBXs: Separate voice and data communications, least expensive solution, simplest technology, network-switched.

  - Consider the need for special capabilities such as special interfaces, function-specific workstations, on-desk teleconferencing.

EXHIBIT III-6

LAN OR CBX SELECTION CRITERIA

- SELECT LAN
  - Mainframe-to-Mainframe Links
  - Extensive Data Base Updates
  - High Speeds Needed Due to Number of Users
  - High Speeds Needed for Video, Color Graphics, Special Applications
  - Protected Investment in PBX
  - Redundant Networks Desired
  - New Building Construction
- SELECT CBX
  - Low Speed Okay
  - Sporadic Terminal/PC Access to Mainframe
  - Physical Constraints on New Cable Installation
  - Frequent Moves
  - Integrated Voice/Data Features Desirable

- Avoid the natural tendency to buy marketing dogma and fallacies in place of facts and figures.

- Conduct an on-site evaluation of systems being considered; interview users of these types of equipment, particularly those in the same industry or those whose companies have structures similar to yours.

- Prepare preference charts and a decision matrix to aid in the feature evaluation, using Exhibit III-3 as a reference.

- The features and benefits of LAN and CBX must be evaluated based on the requirements of today and tomorrow. Apply the features and benefits of each to your situations.

- Defining a realistic projection of future networking needs will help ensure that adequate system capabilities are designed and that unnecessary expenditures are avoided.

- One set of criteria that may be adapted to the planner's neds in selecting either a LAN or a CBX is shown in Exhibit III-6.

b. LAN Selection Criteria

- Some of the factors to be considered in defining the need of a LAN and what capabilities it should possess might be the following:

  - The user's company has invested in free-standing systems (micros and peripherals), which carry a heavy workload, and now wishes to link the systems, sharing resources.

  - Information is to be transported between mainframes.

  - The data base is extensively updated.

- The user's company does not wish to replace or upgrade its recently installed CBX. (A data CBX solution may be appropriate in this case.)

- High-speed capacity is required to accommodate switched video, high resolution graphics, other special applications, or large number of users.

- The company wants separate data and voice networks for security reasons.

- The building or campus is already wired for CATV. Savings are possible on the installation of a LAN.

- A new building is being constructed, or an old building is being extensively renovated. Cable can be installed economically.

c. CBX Selection Criteria

- The user's company is encouraging widespread use of PCs.

- Terminals or micros are used for relatively low-speed access to remote or mainframe computers for electronic mail, word processing, or routing data base inquiries such as inventory/price checks.

- The network will be used experimentally for prototyping data communications applications as preparation for long-term solutions.

- Building construction prevents cabling. Solid concrete walls, cable conduits, and restrictive local building codes prevent new wiring installation.

- People and departments move frequently. CBX can accommodate moves easier than LAN. Central maintenance is desirable.

- The company wants features of integrated voice/data CBX that are not available on dedicated LANs.

d. Voice/Data Integration

- A persistent debate among industry observers is whether the integrated voice/data CBX is actually the right answer for controlling the voice and data needs of today's office environments.

  - For a variety of reasons, many vendors and users of CBX equipment argue that it is more effective to service voice and data functions separately.

  - In support of their view they bring up the following points:

    . Companies generally are not interested in fully automating all their office processes onto one system because CBX systems offer a vulnerable single point of failure.

    . Businesses are skeptical about extending PABX control beyond the realm of voice for two primary reasons: a) System availability and reliability needs are different for voice and data communications systems; and b) User operational needs are different for voice and data communications systems.

    . Image transfer and teleconferencing, which will become important functions in the office of the future, demand transmission rates in the megabit range, and a standard voice CBX is not capable of responding to these requirements without major modifications.

- The technical capacity of integrated voice and data make such CBX switches more expensive than a conventional voice PBX.

- Additional costs are involved in routing data terminal links through a CBX to a data processing site, with no significant improvement in reliability versus a direct connection (on a separate transmission link). These costs often exceed cost savings associated with common use of station wiring for voice and data applications and the elimination of the need for data modems.

- Sophisticated and powerful microcomputer-based CBXs have made substantial inroads into the office environment. Sales of these new CBXs are expected to continue aggressively.

  - Several features and advantages are common to most new CBXs which can result in a major cost savings.

  - The new CBXs have flexible designs which can easily accommodate a variety of configurations, including transmission of voice and data signals over the same standard station line as discussed above.

  - Intelligent telephones as well as standard telephones may be supported without any specialized modifications through functions provided by the software program in the CBX.

- Major cost savings may be achieved through reduced circuit and usage resulting from more efficient use of facilities.

  - This is achieved through sharing of facilities for voice and data, and through greater use of program-controlled features such as least-cost routing and usage restrictions based on class of service.

- Additional savings are generated with the new microprocessor-based CBX as a result of sophisticated functions associated with individual extensions and increased operator productivity through efficient console layout, speed dialing, and other tailor-made functions.

  - The availability and use of these functions gives the operator time to perform other duties as well as handling telephone calls.

- Microprocessor-based CBXs also improve the telephone users' productivity.

  - Improved user efficiency is achieved through better use of advanced functions, which in turn ease the placement of telephone calls, save employee time, and encourage the use of cost-saving and time conserving system capabilities.

  - The new CBX offers better tracking of interoffice personnel movements through simple procedures for rerouting calls to other extensions (call forwarding) when a person moves from one office to another.

  - Automatic call-back features also save time.

  - Finally, the microprocessor-based CBX is adaptable to organizational changes and growth through program control and modular system design.

e. Telecommunications Resale: A Costing Factor

- There are currently more than 300 companies actively engaged in the business of reselling data and voice communications services.

  - This figure doesn't include all the hotels and motels reselling long-distance service.

- The Federal Communications Commission no longer requires that a company file as a telecommunications reseller.

- There are several advantages and opportunities available to any company that sells its surplus capacity and, as an off-shoot of its normal business, becomes a telecommunications reseller. Once the company commits to this idea, it is then able to buy bulk communications services at significantly reduced rates. Voice and data communications services can then be offered to other users within other divisions at much lower rates than the local telephone company.

- Thus, a company turns a traditional cost center into a revenue producer. A few simple calculations show that based upon reasonable assumptions concerning occupancy and business telephone usage, some large companies could realize up to $1 million per year in additional revenues from resale to their own divisions.

- The tax advantages could be an additional consideration, but the exact effects or consequences are unknown at this time, since the U.S. tax structure may shortly be revised.

- In a multi-office building (skyscraper) in a major metropolitan area, it may be advantageous for the larger tenant to let the building owner have a share of the reselling profits, particularly since the owner would be expected to actively market (and otherwise support) the seller's resale activity. In that manner, both parties receive a benefit with a small expenditure of capital.

IV SUMMARY AND CONCLUSIONS

A. CONCLUSIONS

- One motivating factor behind the use of integrated voice/data CBXs is the lower cost associated with being able to utilize existing wiring.
  - The benefits result from utilizing the same cable distribution plant for data transmission, control of the environment, and other automated applications in addition to voice.
  - The (expensive) alternative is to install additional cable and conduit systems to support automation requirements parallel with the cabling already installed for telephone instruments.
- The various CBX offerings promise to move the end user directly into the office of the future environment, but with varying capabilities and risks.
  - Benefits of a CBX with data capability include elimination of modems, acoustic couplers, and/or line drivers at the user terminal. Digital transmission of on-premise data communications and system cost reductions through integrated voice and data switching are also benefits obtained by the end user of CBX equipment.

- A factor of concern to any telecom manager is assessing accurately the major differences in potential product applications and capabilities and relating these to a particular manufacturer's CBX product.

- In considering design alternatives for local office networks, several conclusions are reached:

  - Future office network designs should be based upon combining voice and data. There are few advantages to separating voice from data, while there are strong technical and economic benefits in a combined network.

  - The star topology may be the most immediately suitable for a combined voice/data intra-office network; such a network would be based around a switch similar to that of the computerized CBX which is currently oriented to voice. Internally, the CBX would utilize any physical topology.

  - Traffic characteristics of both data and digital voice must be studied in more detail; the results of such further study would then provide the basis for identifying candidate switching techniques well matched to the requirements, and for evaluating the resource requirements of these alternative switching techniques. It would then be possible to choose a CBX design on the basis of delivered performance as well as cost of the switch.

  - The circuit-switching schemes currently used within voice CBXs may or may not be optimal when switching both voice and data. In order to determine the optimal switching technique, the merits of each must be understood on the basis of resources required in the switch, and on the basis of delivered performance; this would then provide the basis for a cost analysis of the switching facilities.

- Cost is a major decision factor since the switch constitues a major portion of the cost for a star network.

- Major CBX design efforts are being focused on providing greater CBX system throughput and on providing adaquate LAN interfaces. This effort is a direct result of the emergence of LAN technologies having higher transmission speeds, and the need to integrate LANs with CBXs.

- A point that needs to be emphasized is that all major CBX manufacturers are pursuing migration strategies focused around preserving their installed customer base. Thus, it can be anticipated that future hardware/software enhancements will revolve around this central issue.

- The newer network services, such as SPRINT, MCI, and SBS, coupled with AT&T divestiture, have created extensive requirements for network diagnostic and administrative cost reporting systems, as well as a growing need for traffic engineering.

- The LAN environment is extremely cloudy and diverse, with the trend moving away from baseband network and 10 Mbps frequency spectrum and toward broadband and the 25-40 Mhz range.

B. RECOMMENDATIONS

- Often a company that upgrades its telephone system to a new CBX will enjoy significant cost savings, amounting, in some cases, to as much as 25% to 40% over previous telephone expenses.

  - Equipment and operating costs are reduced through the application of state-of-the-art hardware and software features and capabilities.

- The equipment costs which traditionally have accounted for as much as a quarter of a company's telephone bill can be immediately cut with the purchase of a CBX.

  - Interconnect firms lease or sell CBX equipment (either manufactured by themselves or obtained from another non-telephone company) at prices usually considerably lower than rental from the telephone company.

  - With the creation of the Bell Separate Subsidiary, purchase of Bell CBXs also results in comparable cost savings.

- Many other cost-related advantages may accrue from the purchase of a CBX, including fixed costs over the period of the contract, a variety of available purchase options, investment tax credits, depreciation of equipment, and a wide choice of CBX products with many enhanced user features at a lower cost.

- On the operational side, major cost savings can be provided by the use of such features as optimum call routing and the ability of the CBX system to perform automatic call back.

  - For example, long distance phone calls can take advantage of least-cost paths, whether alternate carriers, WATS, leased line, foreign exchange, satellite channel, or the regular direct distance dialing (DDD) lines. This may result in a long distance telephone expanse savings of 10% or more.

  - With the use of advanced computerized CBX featurs such as automatic call back, total long distance telephone expenses can be reduced even further by 20% to 30%.

- For firms receiving large daily volumes of incoming calls, further savings are possible by using a computerized CBX to connect inward coming calls to the first availble operator.

- By this method the number of inward WATS lines or local trunks can be reduced while operator productivity is raised.

- CBX suppliers are finding that the vertical and specialty applications market niches are becoming more and more profitable. The prudent manager will use this information to his advantage when dealing with CBX suppliers.

- The primary reason for either upgrading or replacing existing in-house CBXs should be the issue of system size and capacity and thus, ultimately, costs.

- There is a serious question about the capabilities and feasibility of true integrated voice/data systems. Continued pressure from non-IS executives notwithstanding, the whole issue of integration as it is currently understood should be approached with considerable caution, at least until the method of achieving it, or the technology itself, is clarified.

- Single-vendor LAN configurations, where the same vendor supplies terminal equipment and interfaces as well as the network system and attendant protocols and interfaces, can considerably smooth the installation/maintenance functions.

- The lack of adequate LAN interface standards has had a significant impact on further LAN development. This should be an important management consideration when deciding on which LAN configuration and how to address its component parts.

- INPUT recommends migration toward SNA as an answer to many LAN-related problems in data transmission.

- If SNA is being considered, recognize that it can be a very cost-effective solution to network problems. However, the migration to it is difficult. SNA has many problems, one of which is vendor interfaces into the user's network configuration.

  - However, with SNA, IS will receive full IBM support, which could be invaluable in the event of unresolvable problems. IS also gets management support for buying an established name and reputation. Of course, IS benefits by full compatability between telecommunications and computer systems.

- The network offering expected to issue from IBM is anticipated to be a broadband product operating at the 25-40 Mhz range. This fact is helpful for planning managers who are responsible for network acquisitions but use it with caution, since IBM is frequently unpredictable.

- The competition between LANs and fourth generation CBXs will become increasingly important over the next several years. Weigh carefully all major capital expenditures in these two areas before committing to either. A wrong decision here could be disastrous.

- Because the market for LANs is not well defined, and because the LANs themselves share few features in common with each other, the astute planner will investigate whether LANs are really indicated for his environment. If they are; e.g., as the only cost-effective way to cut telephone and communications costs and free the company from the telco grip, then INPUT suggests that the configuration acquired be as standardized as possible.

  - Standardized products and software reduce maintenance problems.

  - They also reduces costs, especially since hybirds are expensive to acquire, install, and maintain.

- The use of standardized components and modules lessen the probability of interfacing becoming a separate but troublesome issue.

- For the CBX user, the market is clear and the range of options well-defined. Remember: Don't buy just for today's needs. Keep future expansion and user requirements in mind.

About INPUT

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